Pelvic ischemia and quality of life scores after interventional occlusion of the hypogastric artery in patients undergoing endovascular aortic aneurysm repair

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Objective: **The aim of this study was to analyze the pelvic ischemic complications and their impact on quality of life after interventional occlusion of the hypogastric artery (IOHA) in patients undergoing endovascular aortic aneurysm repair (EVAR).**

Methods: **Between January 2004 and April 2012, 638 consecutive patients with aortoiliac aneurysm treated by EVAR were prospectively registered in two teaching hospitals. We identified all EVAR patients who underwent IOHA. Demographic, clinical, and radiologic data were extracted from electronic databases and patient records as requested. All patients who survived the postoperative period took part in a quality of life survey, the Walking Impairment Questionnaire (WIQ), which included four items: pain, distance, walking speed, and stair climbing. Outcome measures included the 30-day rate of pelvic ischemic complications, the buttock claudication (BC) rate at 30 days and during follow-up, and the comparative WIQ scores between patients with persistent BC, those with regressive BC, and those who never had BC after the IOHA procedure.**

Results: **A total of 71 patients (97% men; mean age, 76 years ± 7.69) required 75 IOHA procedures. These were deemed proximal in 44 cases and distal in 31, with use of coil embolization in 64%, Amplatzer plug in 24%, or a combination of coils and plugs in 12%. The technical success rate was 100%. Two patients (2.8%) experienced fatal acute pelvic ischemic complications in the postoperative period after EVAR. Another patient died of iliac rupture during EVAR, leading to an operative mortality rate of 4.3%. Eighteen patients (25.3%) suffered BC, among whom 11 cases resolved at a median follow-up of 42 months. Young age (odds ratio, 0.92; 95% confidence interval, 0.85-0.99; *P* = .03) and distal IOHA (odds ratio, 3.5; 95% confidence interval, 1.01-11.51; *P* = .04) were independent predictors of BC occurrence. The actuarial rate of persistent BC was 85% at 18 months. The WIQ scores were lower for patients with persistent BC (median score, 35.04; interquartile range, 16.36; *P* = .001) compared with patients with regressive BC (median score, 76.5; interquartile range, 36.66; *P* = .02) or those who never experienced BC after the IOHA procedure (median score, 65.34; interquartile range, 10.94; *P* < .0003).**

Conclusions: **Pelvic ischemia associated with IOHA may be severe and lead to fatality after EVAR. Our data show that BC may lead to severe quality of life impairment when it does not regress during follow-up. (J Vasc Surg 2014;60:40-9.)**

Interventional occlusion of the hypogastric artery (IOHA) is commonly performed in patients undergoing endovascular aortic aneurysm repair (EVAR), especially when the aneurysmal process extends to one or both of the iliac artery bifurcations. Potential drawbacks include a higher incidence of pelvic ischemia, with acute or chronic clinical consequences such as sciatic nerve palsy, paraplegia, gluteal necrosis, colonic ischemia, and buttock claudication (BC).[1-6] This last complication is particularly frequent but often ignored or considered benign by clinicians. The full effect of BC, as a marker of chronic pelvic ischemia, and its impact on patients' daily walking ability may be underestimated. Poor clinical assessment criteria, lack of prospectively collected data in reported series, and possible confusion with common mobility-limiting conditions in the target population make the evaluation of BC even more difficult.

Assessment of functional capacity and walking ability is important in determining disease severity, evaluating treatment, and assessing quality of life in claudicants.[7] Treadmill testing is the standard measure to assess walking ability as expressed in meters. However, there is often discrepancy between subjectively experienced daily walking ability,

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Author conflict of interest: none.
Additional material for this article may be found online at www.jvascsurg.org.
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0741-5214/$36.00

http://dx.doi.org/10.1016/j.jvs.2014.01.039

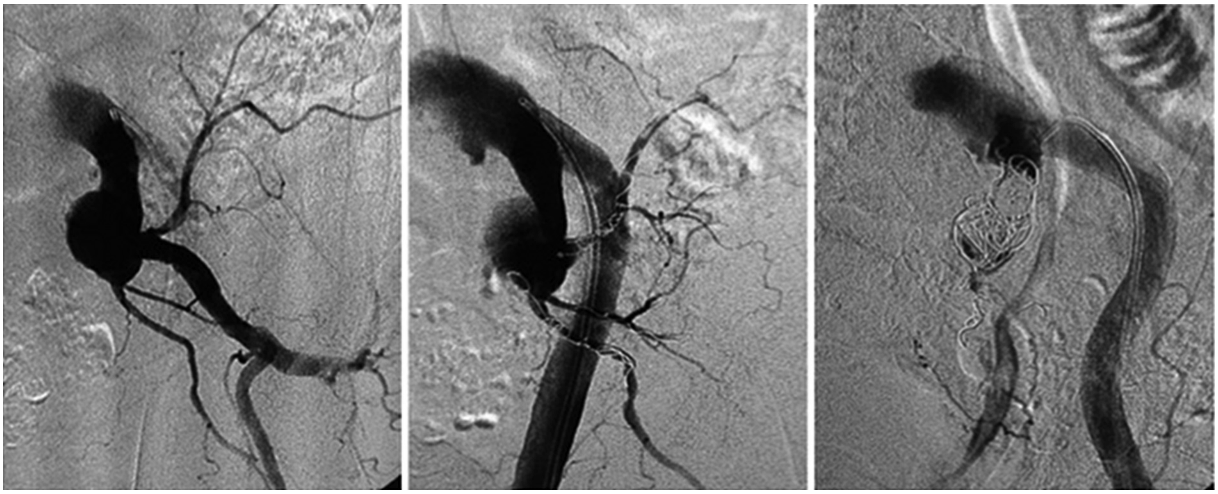

Fig 1. An example of distal hypogastric embolization for associated hypogastric artery (HA) aneurysm. Note the selective placement of coils in all efferent branches from the hypogastric aneurysmal sac.

objective severity of the disease, and walking ability measured on a treadmill in a vascular laboratory.[7-10] A more qualitative approach to document daily walking ability is the Walking Impairment Questionnaire (WIQ), which has been used in several studies to evaluate the effect of treatment in patients with peripheral arterial disease.[11-15]

Current literature contains few data regarding the impact of chronic pelvic ischemia on a patient's daily walking ability, functional capacity, and quality of life after IOHA. The aim of this study was to analyze the pelvic ischemic complications and their impact on the patient's quality of life after IOHA in the setting of EVAR by use of the WIQ.

METHODS

Consecutive patients with aortoiliac aneurysm treated by EVAR between January 2004 and April 2012 were prospectively registered in two teaching hospitals. We retrospectively identified all EVAR patients who underwent unilateral or bilateral IOHA to obtain suitable distal landing zones for the endografts. Sacrifice of any hypogastric artery (HA) was performed in the setting of EVAR for patients deemed at high risk for open repair, when a bell-bottom technique (early in our experience) or an iliac side-branch (later in our experience) was anatomically unfeasible. Our criteria to define high risk for open repair were reported elsewhere.[16] Depending on anatomy and operator preference, patients who needed endograft extension to both external iliac arteries (EIAs) underwent staged bilateral IOHA or unilateral IOHA with preservation of the contralateral HA. This was achieved by contralateral iliac side-branch endografting, contralateral bell-bottom technique, EIA-HA endobypass, or surgical reimplantation of the HA into the EIA. Demographic, clinical, and radiologic data were extracted from prospectively maintained electronic databases and patient records as requested. Age of the patients, gender, comorbid conditions, anatomic indications for IOHA, status of the contralateral HA, and outcomes and technical details of IOHA procedures and any adjunctive procedures were recorded for analysis.

IOHA procedures were classified as proximal or distal according to the placement of the embolization materials, which were respectively placed before or beyond the HA bifurcation. Typically, proximal IOHA was carried out whenever it was anatomically possible by occluding the HA before the bifurcation, except when the presence of an HA aneurysm or ectasia precluded flush occlusion. In these circumstances, distal IOHA was performed by interrupting the primary branches feeding the HA aneurysm sac (Fig 1).

The procedure was performed with a C-arm or in the angiography suite under local, locoregional, or general anesthesia, as appropriate. The interval between IOHA and EVAR procedures was decided by the surgeon and recorded. Technical success for the IOHA was defined as the absence of any antegrade flow distal to the embolization material on the completion angiogram. All perioperative complications were registered and investigated clinically or paraclinically as appropriate, especially the major acute pelvic ischemic complications. According to Chaikof et al,[17] instances of sciatic nerve palsy or paraplegia lasting for more than 24 hours, grade II or III colonic ischemia, and fatal gluteal necrosis were considered major acute pelvic ischemic complications.

During follow-up, both general and EVAR-specific complications were recorded. All patients underwent routine clinical examination, plain film abdominal radiography, and duplex scan or computed tomography angiography at discharge and at 6-month intervals for the first postoperative year and annually thereafter. Special attention was paid to BC as a marker of chronic pelvic ischemia during each of these postoperative clinic visits. BC was defined as walking-induced buttock pain that forces patients to stop after a specific distance or time. Treadmill

Table I. Clinical baseline characteristics

Baseline characteristics	*No. (%) (N = 71)*
Hypertension	49 (69)
Dyslipidemia	24 (34)
Diabetes mellitus	9 (13)
Lower extremity occlusive disease[a]	19 (27)
Smoking	58 (82)
Ongoing	26
Past[b]	32
Never	13
Previously symptomatic coronary artery disease	24 (34)
Cardiac insufficiency[c]	9 (13)
Respiratory insufficiency[d]	23 (32)
Renal failure	39 (55)
Mild (GFR[e] < 80 mL/min)	19
Moderate (GFR < 60 mL/min)	14
Severe (GFR < 30 mL/min)	3
Chronic hemodialysis	3

GFR, Glomerular filtration rate.
[a]Infraclinical (six cases), intermittent limb claudication (four cases), previous successful limb revascularization procedures (nine cases), instances of critical limb ischemia (none).
[b]Smoking cessation for more than 1 year.
[c]Overt manifestations of heart failure or ejection fraction below 40%.
[d]Evidenced by forced expiratory volume in the first second of expiration of less than 1.2 L; vital capacity below 50% of the predicted value as a function of age, sex, and weight; arterial Pa_{CO_2} > 45 mm Hg or Pa_{O_2} < 60 mm Hg; or home oxygen therapy.
[e]GFR as estimated from Cockroft and Gault formula for patients younger than 65 years or the Modification of Diet in Renal Disease formula for patients older than 65 years.

testing to determine maximum walking distance was not performed, but BC was graded according to Fontaine classification as stage 2B or 2A for, respectively, maximum (reported) walking distance superior or inferior to 200 meters.[18] The time elapsed between the IOHA procedure and the complete regression of the BC symptoms was also recorded. Patients with ongoing BC at the end of follow-up were deemed to have persistent BC.

For the impact of persistent BC on the patient's daily walking ability and functional capacity to be determined, all surviving patients were invited between May 2012 and November 2012 to participate in a quality of life survey (the WIQ). This was completed at final follow-up during the last outpatient visit, with the exception of a limited number of patients who requested mail or phone administration. The WIQ (Appendix, online only) is a disease-specific health-related quality of life survey that consists of four subscales exploring four important factors of walking impairment in patients with intermittent claudication: pain, distance, speed, and ability to climb stairs. For each separate domain, subscores of the Likert items were calculated with a Likert scale from 0 (extremely disabling) to 5 (not at all disabling). The subscores were weighted and expressed in percentages of the maximum possible score. Regarding the pain subscale, there were two sets of questions: set A targeted intermittent claudication from vascular origin, and set B targeted walking limitations from other conditions (eg, shortness of breath, joint pain,

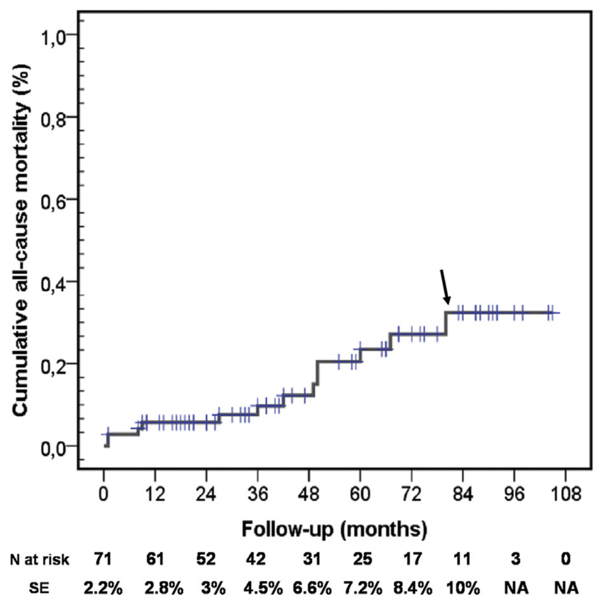

Fig 2. Kaplan-Meier curve for all-cause mortality. *N at risk,* Number at risk; *SE,* standard error. The *arrow* indicates where SE is >10%.

Table II. Causes of death during follow-up

	No.[a] (%) (N = 68)	*Timing, month*
General causes	7 (10)	
Cancer	3 (4)	M27, M21, M8
Cardiovascular	3 (4)	M72, M66, M47
Respiratory insufficiency	1 (1.5)	M49
Aneurysm-related death	2 (3)	
Certain	0 (0)	
Probable[b]	1 (1.5)	M38
Unknown	1 (1.5)	M36

[a]Excluding the three patients who died during the 30-day postoperative period.
[b]This patient had declined a secondary procedure for contralateral type Ib endoleak.

stiffness or aching, chest pain or discomfort). Walking impairment was not deemed to be of vascular origin when set B score was superior to set A score.[15]

The study protocol was approved by our local institutional ethics committee, and all patients gave informed consent to publish their data. Outcome measures included the 30-day rate of major acute pelvic ischemic complications, the BC rate at 30 days after discharge from the hospital, and the cumulative frequency of persistent BC as a measure of chronic pelvic ischemia. Further analysis included the comparative WIQ scores at final follow-up between patients with persistent BC, those with regressive BC, and those who never had BC after the IOHA procedure.

Statistical analysis. Statistical analysis was carried out with SPSS v.20.0 (IBM Corp, Armonk, NY). Categorical variables were compared by χ^2 test significance analysis or Fisher exact test and expressed as a proportion. Continuous

Table III. Endovascular aneurysm repair (EVAR)-specific complications

	Occurrence	*Main cause*	*Management*	*Outcomes*
Endoleaks[a]				
Type Ia	M36	Proximal neck aneurysmal evolution	Palmaz stent	Favorable at M69
Type Ib	M13	Contralateral distal aneurysmal evolution	Patient declined treatment	Death at M38
Type III	M5	Limb migration	Stent graft limb addition	Favorable at M36
Stent graft limb occlusion				
Ipsilateral IOHA	M3	ND	Femoral-femoral bypass	Favorable at M17
Ipsilateral IOHA	M54	ND	Conservative[b]	Favorable at M58

IOHA, Interventional occlusion of the hypogastric artery; *ND,* not determined.
[a]Eleven patients were diagnosed with type II endoleaks and treated conservatively because of spontaneous regression (seven cases) or stable aneurysm sac diameters (four cases).
[b]Nondisabling intermittent thigh claudication treated conservatively.

Table IV. Univariate analysis (end point: buttock claudication [*BC*] at 30 days)

Variable	*BC, % (No.)*	P *value*
Age, years (mean ± standard deviation)	72 ± 7.9 vs 77 ± 7.5	.02
Unilateral vs bilateral IOHA	24 (19/67) vs 25 (1/4)	.74
Single- vs two-stage procedure	31 (5/16) vs 24 (13/55)	.53
Proximal vs distal[a]	18 (9/50) vs 43 (9/21)	.03
Smokers vs nonsmokers	27 (15/55) vs 19 (3/16)	.49
Coils vs plugs	28 (15/53) vs 17 (3/18)	.32
Patent vs occluded contralateral HA	28 (16/58) vs 15 (2/13)	.49
Aortouni-iliac vs aortobi-iliac configuration	22 (4/18) vs 26 (14/53)	>.99
Lower extremity occlusive disease (yes/no)	16 (3/19) vs 29 (15/52)	.36

HA, Hypogastric artery; *IOHA,* interventional occlusion of the hypogastric artery.
[a]Concomitant ectatic hypogastric artery or aneurysm requiring ultradistal embolization.

variables were compared by Student *t*-test or the Mann-Whitney *U* test and expressed as mean ± standard deviation or as median with the range and the interquartile range (IQR). For multiple comparisons, the Kruskal-Wallis test was applied and followed by Bonferroni post hoc correction. Linear regression was used to assess the cross-sectional relationship between WIQ subscores and the time elapsed between the IOHA procedure and the date of survey completion. Cumulative frequencies of individual clinical outcomes were generated by the Kaplan-Meier method. The associations between potential predictors and chronic pelvic ischemia were assessed by univariate methods followed by stepwise multivariate logistic regression analysis. Statistical significance was set at $P \leq .05$.

RESULTS

Population description. Among 638 patients who underwent EVAR during the study period, we identified 71 patients (69 men, two women) who required IOHA. The mean age of this cohort was 75.8 ± 7.69 years. Clinical baseline characteristics are listed in Table I. For suitable distal landing zones to be obtained for 53 bifurcated and 18 aortouni-iliac endografts, a total of 75 HAs were occluded intentionally in these 71 patients. The main anatomic reasons for interrupting the HA were an insufficient distal neck (<10 mm) in the common iliac artery (51 cases), an associated HA aneurysm (23 cases), or a short (<30 mm) common iliac artery in the last patient. The IOHA procedure was unilateral in 67 patients (94%) and bilateral in 4 patients (6%); the latter group included three cases of associated bilateral HA aneurysm and one case of unsuitable distal landing zone in both common iliac arteries. All four bilateral IOHA cases were performed as a staged procedure. Five other patients of the unilateral group had prior chronic contralateral HA occlusion from atheromatous lesions. This resulted in a total of 13% of patients (9 of 71) with bilateral HA interruption. In nine other patients who would have otherwise required a bilateral IOHA procedure, we performed some adjunctive procedures to preserve antegrade perfusion to the contralateral HA. These included two cases of contralateral iliac side-branch endografting, two cases of endobypass between the HA and EIAs (banana technique), two cases of surgical reimplantation of the HA into the EIA, and three cases of the bell-bottom technique. Among the remaining patients, the contralateral HA was patent and deemed healthy in 40 (56%), ectatic in 8 (11%), or with significant (≥70%) stenoses in 5 (7%).

Procedural results. The IOHA procedure was carried out by coil embolization in 48 HAs (64%), the Amplatzer plug in 18 arteries (24%), or a combination of coils and plugs in 9 arteries (12%). The IOHA was deemed proximal in 59% of cases (44 arteries in 42 patients) and distal in 41% (31 arteries in 29 patients). The latter group contained the 23 patients with associated HA aneurysms. All IOHA procedures were successfully completed, achieving an initial 100% technical success rate. This was performed in the same operative setting as EVAR in 16 patients (18%) or

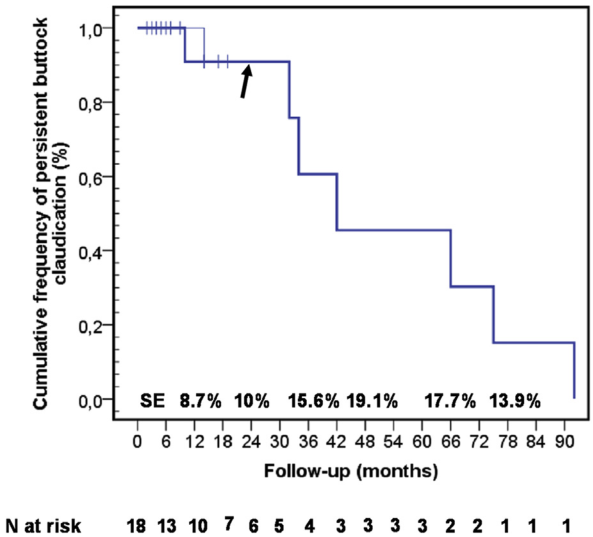

Fig 3. Kaplan-Meier curve for persistent buttock claudication (BC). *N at risk,* Number at risk; *SE,* standard error. The *arrow* indicates where SE is >10%.

as a staged procedure in 55 patients (82%). The median time elapsed between the two procedures was 11 days (IQR, 2-20 days; range, 0-103 days). Unplanned adjunctive procedures were required at the time of EVAR to deal with three instances of intraprocedural adverse events. An 83-year-old patient experienced acute stent graft thrombosis treated by axillobifemoral bypass after failed thrombectomy attempts. A second patient had acute stent graft limb occlusion ipsilateral to the embolized HA. A crossover femoral-femoral bypass was performed after failed thrombectomy attempts. A third patient underwent contralateral HA reimplantation into the EIA because of inadvertent coverage of this artery during EVAR.

Thirty-day postoperative outcomes. Within the first 30 days after the EVAR procedure, two patients (2.8%) experienced fatal acute pelvic ischemic complications: one case of colonic ischemia and one case of partially resolutive paraplegia. The former was an 82-year-old patient who underwent unilateral IOHA and EVAR in two sessions and suffered stent graft thrombosis 48 hours after EVAR. The latter was a 73-year-old patient who became paraplegic the day after EVAR, with the occlusion of the contralateral internal-external iliac endobypass diagnosed on computed tomography angiography. Another patient died of iliac rupture during EVAR before any salvage procedure could be performed, leading to a 30-day mortality rate of 4.3% (3 of 71). In addition, there were two cases of stent graft limb occlusion ipsilateral to the IOHA, at days 14 and 28 after EVAR, which were successfully treated by a crossover femoral-femoral bypass. No cases of gluteal necrosis were observed, but the previously mentioned patient who experienced paraplegia displayed a gluteal ischemic rash. In addition, three systemic nonfatal complications were noted: renal failure worsening in two patients and acute coronary syndrome in another. For comparative purposes, in EVAR patients who did not undergo an IOHA procedure, no cases of acute pelvic ischemia were diagnosed, and the 30-day death rate was 1.2% (7 of 563) during the same period ($P = .06$).

Medium-term outcomes. The median follow-up was 42 months (IQR, 21-72 months; range, 1-105 months). During this period, there were 13 deaths (Fig 2), including the three cases of in-hospital mortality mentioned before and 10 later deaths. Five-year survival rate was 77%. The death causes are summarized in Table II. No late aneurysm-related deaths attributable to the IOHA procedure were documented, but two patients died of unknown causes, including one patient who declined a secondary procedure for a type Ib contralateral endoleak. Sexual dysfunction was not routinely sought with a dedicated questionnaire, but a 61-year-old patient reported erectile dysfunction 2 months after the IOHA procedure. Table III details the principal EVAR-specific complications depicted in this cohort during follow-up, with their time and cause of occurrence, dedicated treatment, and outcomes. No complication was directly attributable to the IOHA, although two patients showed stent graft limb occlusion ipsilateral to the sacrificed HA (Table III).

No further patients were diagnosed with acute pelvic ischemia during follow-up. Concerning chronic pelvic ischemic symptoms, 18 patients (25.3%) suffered BC at 30 days after discharge from the hospital. BC was categorized as Fontaine stage 2B in 11 patients (61%) and 2A in 7 (39%). Three BC cases were bilateral. In contrast, inadvertent coverage of one HA occurred in three cases of the 567 other EVAR patients during the same period but had remained totally asymptomatic. In univariate analysis (Table IV), patients who experienced BC after IOHA were significantly younger than the nonclaudicants (72 ± 7.9 years vs 77 ± 7.5 years; $P = .02$). The frequency of BC was also higher (43% [9 of 21] vs 18% [9 of 50]; $P = .03$) in patients who underwent distal IOHA for associated HA aneurysm (Fig 1). All other factors (Table IV) were nonsignificant. In multivariate analysis, young age (odds ratio, 0.92; 95% confidence interval, 0.85-0.99; $P = .03$) and distal IOHA for associated HA aneurysm (odds ratio, 3.5; 95% confidence interval, 1.01-11.51; $P = .04$) remained the only independent predictors of BC occurrence after IOHA.

During the median follow-up of 42 months, 11 cases of BC resolved spontaneously and none worsened with time. Fig 3 shows the cumulative frequency of persistent BC. In patients with persistent BC, the median time elapsed between the IOHA procedure and the last follow-up visit was 42 months (IQR, 32-75 months; range, 10-92 months). The actuarial rate of persistent BC (Fig 3) was 85% at 18 months.

Chronic pelvic ischemia and quality of life scores. A total of 58 patients, excluding the 13 previously mentioned death cases, were invited to participate in the quality of life survey. Eight patients could not complete the WIQ because of their neurologic status (stroke, four

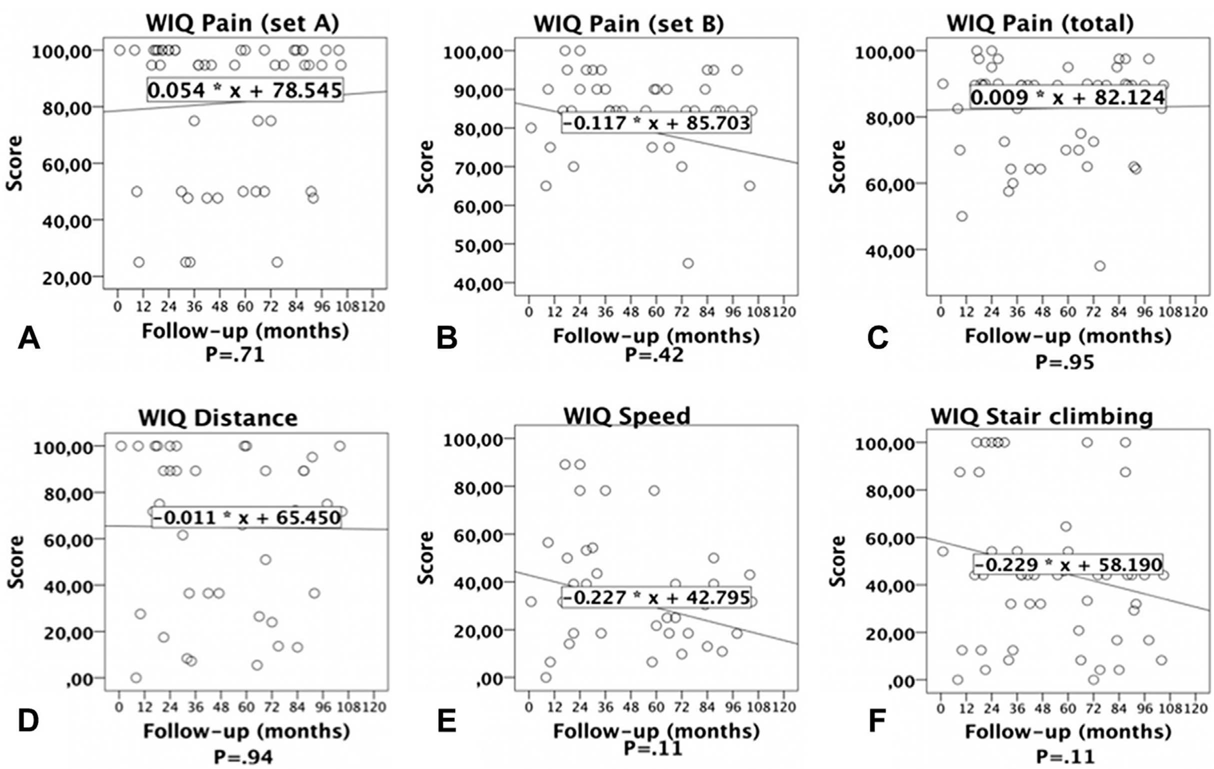

Fig 4. Walking Impairment Questionnaire (*WIQ*) subscores plotted as a function of follow-up month. Linear regression of WIQ subscores and cross-sectional follow-up month are shown. **A,** WIQ pain (*set A*). **B,** WIQ pain (*set B*). **C,** WIQ pain (*total*). **D,** WIQ distance. **E,** WIQ speed. **F,** WIQ stair climbing. *P* values are by Pearson correlation.

cases; dementia, four cases), yielding an 86% (50 of 58) response rate. Timing of survey completion from the IOHA procedure varied from patient to patient (median, 45.5 months; IQR, 24-78 months). Linear regression of each of the four WIQ subscale scores with cross-sectional follow-up month is illustrated in Fig 4. There was no statistically significant association between longer follow-up and any of the four WIQ subscale linear regression coefficients. Fig 5 shows a detailed comparison of WIQ subscores between three groups of patients: those with persistent BC, those with regressive BC, and those who never had BC. Patients who experienced persistent BC showed significantly poorer subscores for walk pain (set A subscore [$P < .0003$] and total [$P = .0003$]), walk distance ($P < .0003$), and stair climbing ($P = .0003$) as opposed to patients who never had BC. The subscores also differed between patients with persistent BC and those with regressive BC, although this did not reach statistical significance for distance ($P = .06$) and stair climbing ($P = .18$). There were no subscore differences in any of the four WIQ subscales when patients with regressive BC were compared with those who never had BC. Similarly, the total WIQ score, indicating functional capacity and walking ability as quality of life markers, did not differ between patients with regressive BC and those who never experienced BC ($P > .999$ [Bonferroni correction]). The total WIQ score was, however, significantly lower in patients with persistent BC (median score, 35.04; IQR, 16.36; Kruskal-Wallis test, $P = .001$) compared with patients with regressive BC (median score, 76.5; IQR, 36.66; Bonferroni correction, $P = .02$) or those who never experienced BC after the IOHA procedure (median score, 65.34; IQR, 10.94; Bonferroni correction, $P < .0003$). All three groups of patients displayed comparable subscores for WIQ pain set B questions that target nonvascular walking impairment from common mobility-limiting conditions. Further analysis showed that regardless of the time elapsed between survey completion and the IOHA procedure (Fig 6), patients with persistent BC had significantly poorer WIQ total scores and subscores (pain A, distance, and stair climbing) than those of patients with regressive BC or patients who never had claudication.

DISCUSSION

In this study, we focused on pelvic ischemia, patient functional capacity, and walking ability as quality of life markers after IOHA in the setting of EVAR. Our findings confirm that acute pelvic ischemia associated with IOHA occurs rarely but can be severe and, in some cases, fatal. In this study, chronic pelvic ischemic symptoms as underlined by BC were more common and likely to be relevant in the youngest patients who underwent distal IOHA for associated HA aneurysm. Our data also show that

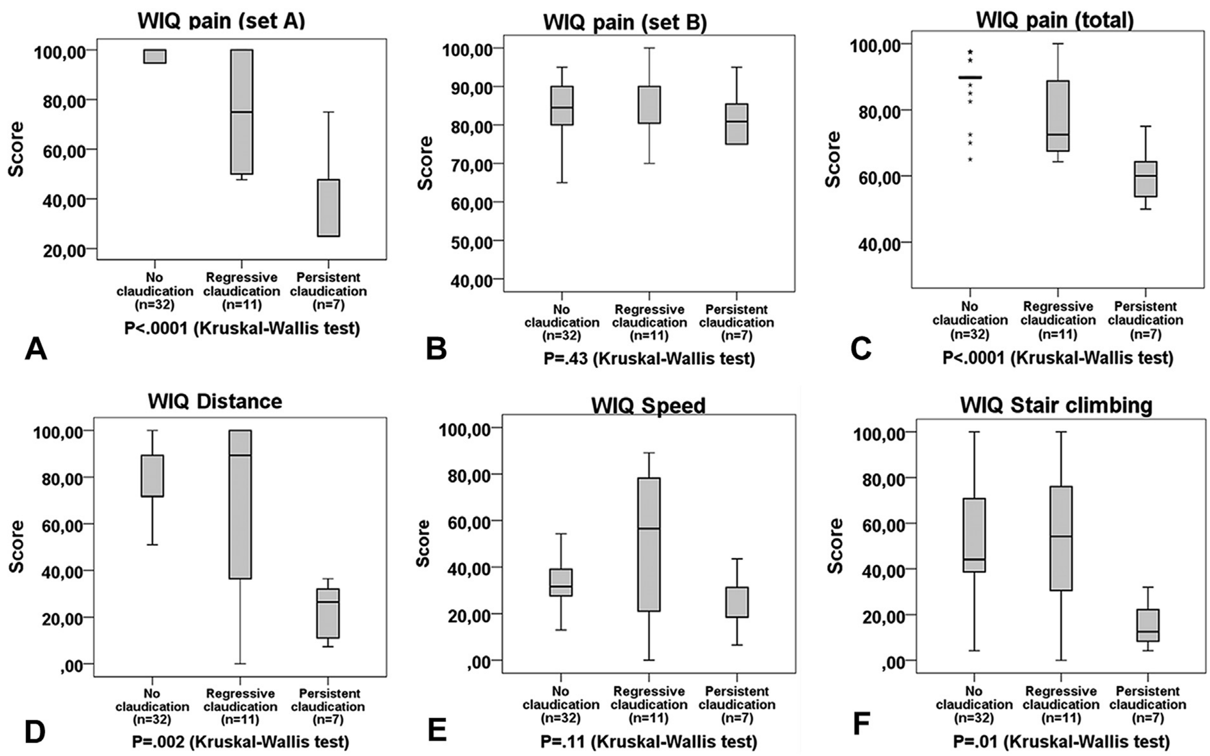

Fig 5. Walking Impairment Questionnaire (*WIQ*) subscores in patients with ongoing or persistent buttock claudication (BC), those with regressive BC, and those who never had BC after hypogastric artery (HA) embolization procedures. Significant *P* values by Kruskal-Wallis test were followed by Bonferroni post hoc correction. **A,** WIQ pain (set A questions): [persistent BC vs regressive BC; $P = .015$]; [persistent BC vs no BC ever; $P < .0003$]; [regressive BC vs no BC ever; $P = .11$]. **B,** WIQ pain (set B questions): No statistically significant differences between the three groups. **C,** WIQ pain (total): [persistent BC vs regressive BC; $P = .015$]; [persistent BC vs no BC ever; $P = .0003$]; [regressive BC vs no BC ever; $P = .12$]. **D,** WIQ distance: [persistent BC vs regressive BC; $P = .06$]; [persistent BC vs no BC ever; $P < .0003$]; [regressive BC vs no BC ever; $P > .999$]. **E,** WIQ speed: No statistically significant differences between the three groups. **F,** WIQ stair climbing: [persistent BC vs regressive BC; $P = .183$]; [persistent BC vs no BC ever; $P = .003$]; [regressive BC vs no BC ever; $P > .999$].

regardless of the time elapsed since the IOHA, patients with persistent BC had significantly poorer functional capacity, walking ability, and quality of life compared with those with regressive BC or those who never had claudication.

The rate of acute pelvic ischemic complications after IOHA was 2.8%, whereas it was nil in the remaining 567 EVAR patients who did not undergo an IOHA procedure. Previous reports describing major acute pelvic ischemia in patients undergoing IOHA have reported rates ranging from 0% to 18%.[1-5,19-24] The factors that influence the development of pelvic ischemia after IOHA are unknown, but the adequacy of the pelvic collateral circulation seems important.[25] Bilateral HA interruption, failed collateral anastomotic network, and atherothrombotic microembolization have been suggested as possible causes of acute pelvic ischemic complications.[1-6] These disastrous occurrences are also more likely in patients who experienced severe perioperative hypotension, those with associated splanchnic arterial occlusive disease, or those with low cardiac output due to associated heart failure.[26] Because of the low incidence of acute pelvic ischemia after IOHA in this study, we could not analyze any prognostic factor for acute pelvic ischemic complications.

Thirty-day mortality, general complications, and cumulative mortality during follow-up were in agreement with our previously reported outcomes for EVAR patients at high risk for open repair.[16,27,28] Although acute pelvic ischemic complications did not occur in any of the 567 contemporary EVAR patients without IOHA, the 30-day mortality rate was not significantly different between these patients and the subgroup included in this analysis. With respect to EVAR-specific complications during follow-up, we did not observe any type II or type Ib endoleak in the setting of previously embolized HA. This is consistent with previous data.[1-6] Deploying additional stent grafts into EIAs may compromise long-term stent graft patency.[29] In this study, a total of six endograft limbs ipsilateral to the IOHA were occluded when adverse events were computed in both perioperative and follow-up

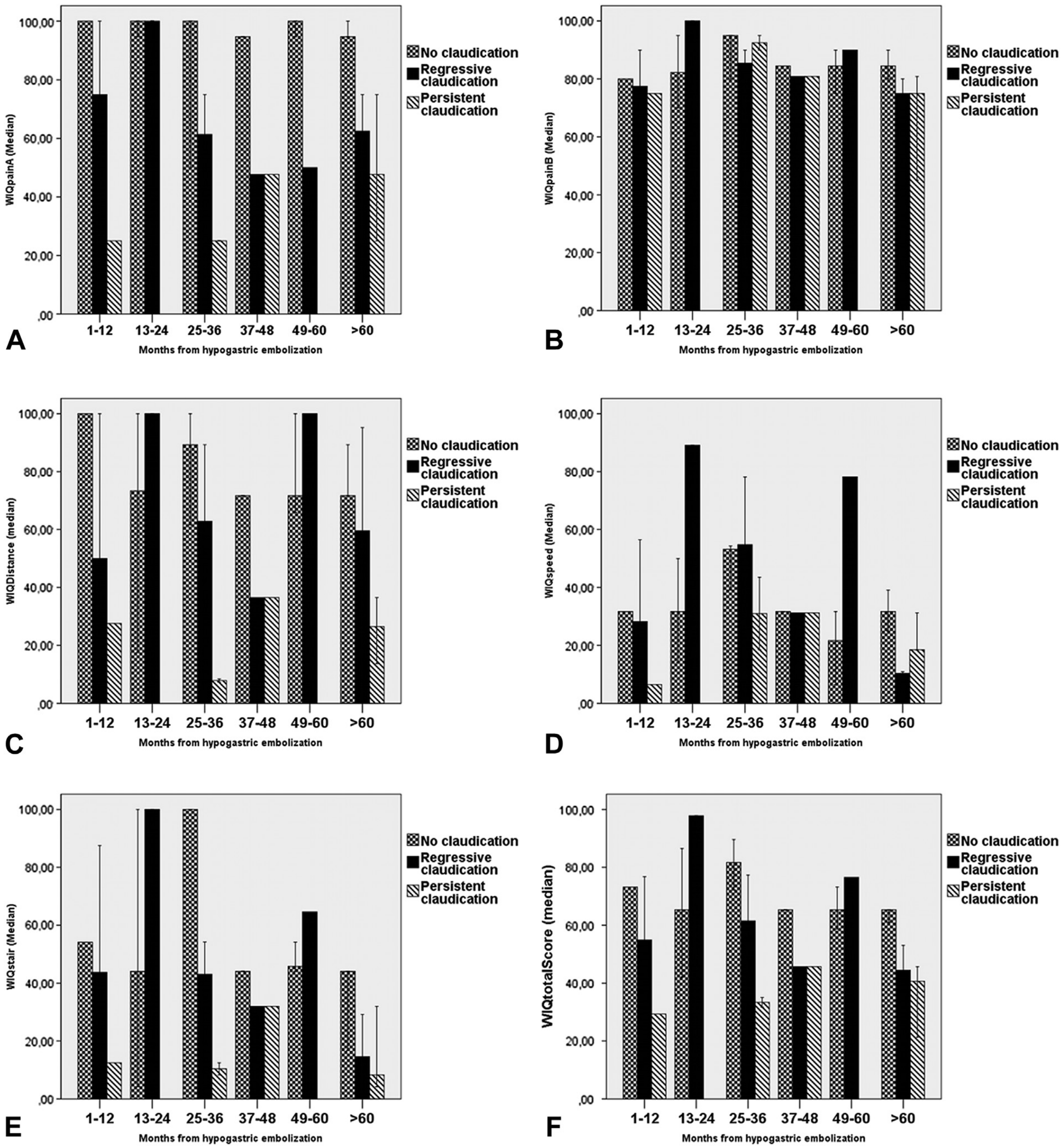

Fig 6. Walking Impairment Questionnaire (*WIQ*) score and subscores. **A,** WIQ pain A. **B,** WIQ pain B. **C,** WIQ distance. **D,** WIQ speed. **E,** WIQ stair climbing. **F,** WIQ total score according to timing of survey completion and patient symptom status. *Error bars* are 95% confidence interval.

periods. The question of whether IOHA favors stent graft limb occlusion warrants further exploration.

Twenty-five percent of patients experienced BC, which had disappeared in 61% of cases during follow-up, corresponding with previous literature data reporting 16% to 55% rates of BC and natural regression in 13% to 100% of cases.[25,30] Previous reports have emphasized the role of more proximal IOHA to prevent BC.[3,19,24,30-32] Consistent with these data, distal IOHA for associated HA aneurysm was an independent predictor of BC occurrence after IOHA in our cohort. Surprisingly, the rate of BC did not differ significantly between patients with an occluded or patent contralateral HA. The relatively small sample size may account for these data.

Our data also show that BC was significantly associated with young age. It is uncertain whether this increased risk is solely attributable to their age rather than to their activity level. Elderly patients are likely to have occult chronic pelvic ischemia because of sedentary lifestyles and possibly more common comorbid conditions. This emphasizes the interest in BC self-evaluation by patients and by clinicians with use of robust qualitative tools such as the WIQ scores. Moreover, these data provide further insight into the fact that young patients with complex iliac anatomy should undergo open repair. Alternatively, the iliac side-branch endograft could be favored if the physiologic status of a young patient cannot withstand an aortic cross-clamping procedure.

Overall, the WIQ subscores were low, even in the absence of BC. This reflects the high frequency of mobility-limiting conditions in the target population (cardiac failures, chronic obstructive pulmonary disease, osteoarthritis, and advanced age). The quality of life of patients with persistent BC was significantly more impaired compared with that of patients with regressive BC and those who never experienced BC after the IOHA procedure.

A major limitation of this study lies in the fact that we did not assess the WIQ scores at baseline and at different points during follow-up, thus precluding a comparison of preoperative and postoperative quality of life. Longitudinal quality of life data would have resulted in a more meaningful comparison between patients who experienced persistent BC and the controls. Another limitation is that erectile dysfunction was not included in the fields chosen to be investigated by a dedicated questionnaire. The profunda and inferior mesenteric arteries would also be valuable anatomic points to investigate. However, this study has several strengths that make the results valid and substantial. To the best of our knowledge, this is the first study in the world literature using the WIQ to assess functional capacity and walking ability in patients with BC after IOHA procedures. Our use of the validated WIQ instrument contrasts with the inconsistent and subjective assessment measures used in previous studies. Moreover, this study is one of the largest and most comprehensive series on the topic so far.

CONCLUSIONS

Pelvic ischemia associated with IOHA may be severe and lead to fatality after EVAR. Chronic pelvic ischemia as underlined by BC was more common and likely to be relevant in the youngest patients who underwent distal IOHA for associated HA aneurysm. Our data show that BC may impair the patient's quality of life when it does not regress during follow-up.

AUTHOR CONTRIBUTIONS

Conception and design: EJ, SB, RH
Analysis and interpretation: EJ, SB
Data collection: EJ, SB, MB, NS, JB, PM, RH
Writing the article: EJ
Critical revision of the article: EJ, SB, MB, NS, JB, PM, RH
Final approval of the article: EJ, SB, MB, NS, JB, PM, RH
Statistical analysis: EJ, SB
Obtained funding: Not applicable
Overall responsibility: RH

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Submitted Nov 4, 2013; accepted Jan 19, 2014.

Additional material for this article may be found online at www.jvascsurg.org.

APPENDIX (online only). An English copy of the Walking Impairment Questionnaire (WIQ).

I. Walking impairment: these questions ask about the reasons why you had difficulty walking. We would like to know how much difficulty you had walking because of each of these problems during the last week. By difficulty, we mean how hard it was or how much physical effort it took to walk because of each of these problems.

A. PAD-Specific Questions	Leg	Degree of difficulty					Score
	Right Left Both	None	Slight	Some	Much	Very	
1. Pain, aching or cramps in your calves (or buttocks?		4	3	2	1	0	
% Score = (individual score/4) x 100							

B. Differential Diagnosis	Degree of difficulty					Score
	None	Slight	Some	Much	Very	
1. Pain, stiffness, or aching in your joints (ankles, knees, or hips)?	4	3	2	1	0	
2. Weakness in one or both of your legs?	4	3	2	1	0	
3. Pain or discomfort in your chest?	4	3	2	1	0	
4. Shortness of breath?	4	3	2	1	0	
5. Heart palpitations?	4	3	2	1	0	
6. Other problems? (please list)	4	3	2	1	0	

II. Walking distance: Report the degree of physical difficulty that best describes how hard it was for you to walk on level ground without stopping to rest for each of the following distances during the last week:

Distance	Degree of difficulty					Weight	Score
	None	Slight	Some	Much	Unable	Feet	
1. Walking indoors such as around your home?	4	3	2	1	0	x20 =	
2. Walking 50 feet?	4	3	2	1	0	x50 =	
3. Walking 150 feet (1/2 block)?	4	3	2	1	0	x150 =	
4. Walking 300 feet (1 block)?	4	3	2	1	0	x300 =	
5. Walking 600 feet (2 blocks)?	4	3	2	1	0	x600 =	
6. Walking 900 feet (3 blocks)?	4	3	2	1	0	x900 =	
7. Walking 1500 feet (5 blocks)?	4	3	2	1	0	x1500 =	
% Score = (Sum individual Scores/14 080) x 100							

III. Walking speed: Report the degree of physical difficulty that best describes how hard if was for you to walk one city block on level ground at each of these speeds without stopping to rest during the last week:

Speed	Degree of difficulty					Weight	Score
	None	Slight	Some	Much	Unable	Mph	
1. Walking 1 block slowly?	4	3	2	1	0	x1.5 =	
2. Walking 1 block at an average speed?	4	3	2	1	0	x2.0 =	
3. Walking 1 block quickly?	4	3	2	1	0	x3.0 =	
4. Running or jogging 1 block?	4	3	2	1	0	x5.0 =	
% Score = (Sum individual Scores /46) x 100							

IV. Stair climbing: for each of these questions, report the degree of physical difficulty that best describes how hard it was for you to climb stairs without stopping to rest during the past week:

Stairs	Degree of difficulty					Weight	Score
	None	Slight	Some	Much	Unable	No of stairs	
1. Climbing 1 flight of stairs	4	3	2	1	0	x12 =	
2. Climbing 2 flights of stairs	4	3	2	1	0	x24 =	
3. Climbing 3 flights of stairs	4	3	2	1	0	x36 =	
% Score = (Sum individual Scores/288) x 100							

PAD, Peripheral arterial disease.